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AUTHOR Stead, Keith
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ABSTRACT

This research sought to identify reasons why the study of science was being rejected by girls and Polynesian students. From eight schools chosen to give a representative coverage of ethnic grouping (Maori, European, Pacific Island) and type (single sex, coed, rural, urban, primary, intermediate, secondary), 20 Form 1 to 4 classes were administered five cognitive measures and a science questionnaire (included in an appendix). In addition, 26 students and their parents were interviewed separately. Results indicate significant differences between sexes, European and Maori students, and European and Pacific Island students. Student responses during interviews tended to focus primarily on attitudes toward subjects (like/dislike) or their perceived value (important/unimportant). Typical parental responses are presented under the following categories: function of school; importance of school subjects; nature of science; necessity of science knowledge in the everyday world; who studies science; sex differences and science; and ethnic differences and science. Parental attitudes and sex/ethnic factors noted indicate that teachers need to: (1) explore, challenge, modify, and extend students' beliefs about science; (2) identify students' perceptions of other people's views; and (3) develop parents' outlooks on science beyond those which they themselves have developed in school. (JN)

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OUTLOOK ON SCIENCE

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WORKING PAPER No. 50

OUTLOOK ON SCIENCE

A working paper of the Learning in Science Project

Keith Stead

June 1982

INTRODUCTION

This paper developed out of research which sought specifically to identify the reasons why the study of science was being rejected by two readily identifiable groups; namely, of girls, and of Polynesian students. The following tables illustrate the degree of this 'rejection':

Table 1: Mean percentages of girls and boys in the 5, 6, and 7 forms who took science options for the five years 1976-1980 inclusively.

	Fifth Form		Sixth Form		Seventh Form	
	Girls	Boys	Girls	Boys	Girls	Boys
Science	50.9	68.7	-	-	-	-
Biology	29.2	11.7	74.2	52.8	67.1	49.2
Chemistry	0.9	3.8	22.8	37.4	35.8	52.8
Physics	0.7	5.9	14.6	48.5	22.8	56.4

Source: Annual Education Statistics of New Zealand, Dept. of Ed.

These figures show that when students choose their courses of study at the fifth form, boys elect to stay with science (or the physical sciences, if available within the school) while many girls tend to prefer to change to biology. This initial disproportionate representation of the sexes, in both the physical and biological sciences, is maintained into the sixth and seventh forms, and beyond. University figures show a similar disproportionality between the sexes where, even in the biological sciences, proportionately more males than females obtain science degrees.

A similar situation is reflected by the comparable figures illustrating the Maori/non-Maori[(1)] enrolment figures.

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(1) This is the only ethnic breakdown of enrolment figures recorded by the Department. In this paper, 'Polynesian' refers to Pacific Islanders as well as Maori students.

Table 2: Mean percentage of students classified as Maori and Non-Maori at the 5, 6, and 7 form levels who took science options for the five years 1976-1980 inclusively.

	Fifth Form		Sixth Form		Seventh Form	
	Non-Maori	Maori	Non-Maori	Maori	Non-Maori	Maori
Science	61.8	47.2	-	-	-	-
Biology	20.2	22.8	64.2	57.1	57.0	53.5
Chemistry	2.6	0.5	31.0	15.3	45.9	31.6
Physics	3.6	1.0	33.3	19.1	42.2	34.0

Source: Annual Education Statistics of New Zealand, Dept of Ed.

Thus, except for the fifth form biology, proportionately more Non-Maori students choose to continue studying science than do Maori students.

SEEKING EXPLANATIONS

Initial observations of students in science classrooms, and ad hoc individual group interviews with them and their teachers, suggested that the decisions students made about the relevancy, importance, application, and so on, of science were apparently influenced by a variety of seemingly incidental beliefs, values, attitudes, intentions, feelings, and opinions. This miscellany of variables was collectively referred to as the students' "outlook" on science and it was decided to systematize the exploration of these outlooks by first broadly surveying a large number of students before selecting a representative few for intensive in-depth case-study analysis.

METHODOLOGY

(a) Initial survey

From eight schools chosen to give a representative coverage of ethnic grouping (Maori, European, Pacific Island) and type (single sex, coed, rural, urban, primary, intermediate, secondary), 20 classes (form one to form four inclusive) were given a series of tests by the investigator. These included TOSCA (Reid, et al, 1981), Hidden Figures (Ekstrom, French and Harman, 1976), Intellectual Academic Responsibility Questionnaire (Crandell, Katkovsky, & Crandell, 1965), Cognitive Style (Kagan, Moss, and Siegel, 1963), and a science questionnaire devised by the investigator.

This science questionnaire sought to explore possible relationships between 'science ability' (as measured by the questionnaire) and those student characteristics measured by the previous measures. Also, it provided for particular attitudinal responses to science to be expressed by the students which were followed up in subsequent one-to-one discussions with the investigator (see Appendix A).

(b) Pupil Interviews

From these classes 26 students were initially chosen to represent, as closely as possible, each of the school, form, sex, and ethnic variables (see Appendix B). Their teachers were consulted to provide additional information such as PAT scores, report grades, likely support from parents, and the ability of the students to converse freely with an adult.

Each pupil was interviewed individually on a variety of occasions and various techniques were used in these interviews to establish the pupil's outlook on the various school subjects studied by each student; a selection from his/her hobbies and interests, sports; vocational interests, where now; and occasionally, a stereotype adult role (eg being a housewife or doing Dad's job).

The various techniques included -

(i) interviwing each pupil about his/her response to the science questionnaire;
(ii) developing with each pupil a 'Repertory Grid' (Stead, 1981) using Kelly's Personal Construct Theory (Kelly, 1955);
(iii) interviewing each pupil about a three-dimensional model of their own personal construct system (Stead, 1981).

(c) Parent Interviews

Informal, unstructured interviews were sought with the parents of all the students. These were usually held in the evenings at the parents' homes and lasted between 45 minutes and 2 hours (average about 1 hour). An attempt was made to reveal the parents' attitudes and beliefs about schooling in general, and about science in particular. Also, information was sought on the degree of support given to their children's school work; sex differentiation in rearing their children; ethnic issues; and beliefs about the degree of control they felt they had in determining the outcomes of their lives. The interviews were audio-taped for later transcription and analysis.

(d) Final Surveys

In order to explore the determinants of student intention to study, or not to study, science beyond the fourth form year, surveys based on Ajzen and Fishbein's (1980) "Theory of Reasoned Action" (TRA) model were administered to fourth and fifth form students.

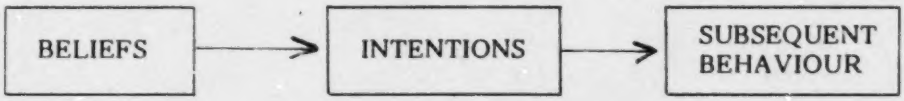


Figure 1 Factors determining a person's behaviour

The model (see Figure 1) suggests that a pupil's intentions and subsequent behaviour, eg to study chemistry next year, are influenced partly by the pupil's beliefs about chemistry (eg how valuable/relevant studying chemistry will be to me) called objective beliefs and partly by a pupil's beliefs about what other people think he or she should or should not do, and the pupil's motivation to comply, eg, Mum thinks that it would be a waste of my time to study chemistry. These are called subjective beliefs.

A student's subjective belief is an opinion held by the student that a specific person, important to the student (eg a parent), thinks about the likely consequence of the student behaving in a particular way, eg, "Dad thinks I should study science because ...". The subjective norm is a student's belief that most people, important to the student in question, thinks he/she should exhibit particular behaviour. This too can influence actual behaviour.

This model, described more completely in Figure 2, was adopted because the interviews with parents and pupils suggested that the relative contribution of these two factors to whether or not males/females and various ethnic groups do or do not study science subjects may differ.

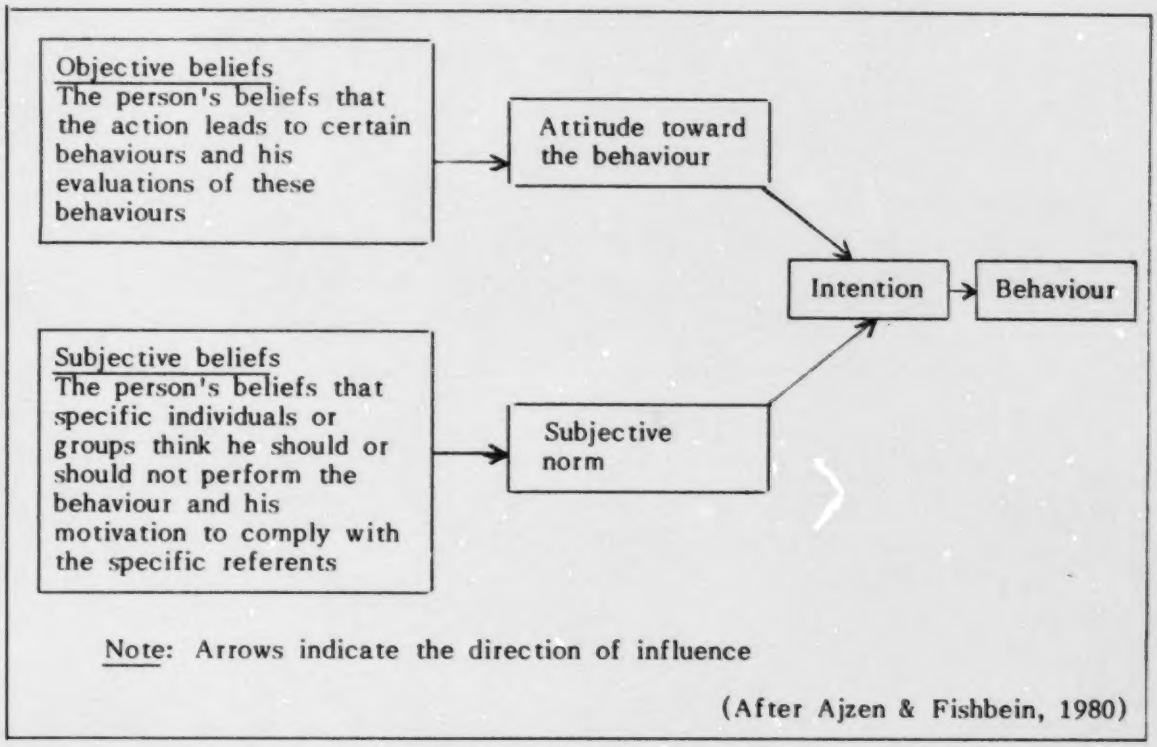

Objective beliefs
The person's beliefs that the action leads to certain behaviours and his evaluations of these behaviours
Attitude toward the behaviour
Intention
Behaviour
Subjective beliefs
The person's beliefs that specific individuals or groups think he should or should not perform the behaviour and his motivation to comply with the specific referents
Subjective norm
Note: Arrows indicate the direction of influence
(After Ajzen & Fishbein, 1980)

Figure 2 The TRA Model in greater detail

RESULTS

(a) Initial Survey

Appendix C shows the significant differences between -

(i) the sexes,

(ii) European and Maori students, and

(iii) European and Pacific Island students.

The PAT data were obtained from student record cards, and all other data from instruments administered by the investigator. The findings from the attitudinal section of the science questionnaire are also included.

The PAT differences were those already well known to teachers although the expected sex differences in arithmetic and, perhaps vocabulary, were not found. However, sex differences (with boys scoring higher than girls) were found in TOSCA. TOSCA may be considered as a measure which probes the same general cognitive skills as the PAT reading, vocabulary, and arithmetic. The ethnic differences in both the PAT and TOSCA measures were all of a high order and would suggest the possible existence of at least one specific ethnic factor which operates to disadvantage the Polynesian students.

The Intellectual Academic Responsibility (IAR) measures revealed no significant sex differences and a significant ethnic difference on only the positive IAR European/Maori group. ie European students were more likely to accept responsibility for their successes and to de-emphasise the role of external factors such as luck (and thereby, to exhibit a higher 'internal' locus of control) than are the Maori students. No ethnic differences appeared when considering where attribution of responsibility for failure would be apportioned.

The Kagan and Siegel (1963) "Test of Cognitive Style" measures revealed no significant sex differences which would appear to contradict the findings of Archer (1970). However, Archer's study considered students of a younger age group (he used only Form 1 students; mean age of 143.62 months) and age related differences have been noted by other researchers (see Ausburn and Ausburn, 1978 for a full review). Consequently, the wide age range of this survey could well have masked specific age related differences.

European students tended to score higher than the Maori students in both the 'descriptive' and the 'relational' modes of the cognitive style test. These were the only ethnic cognitive style differences noted and support the slight (although not statistically significant) trends observed by Harker (1976) who used the same measure but with younger (9 year old) children.

The sex differences on the 'Field dependence/Field independence' measure was in keeping with other research (see Maccoby & Jacklin, 1974) and would support the hypothesis concerning the possible sex-related differences in perception. Similarly, the European/Maori differences lend support to the notion that European students are more likely than Maori students to use an analytical rather than a global strategy when responding to such perceptual problems (for an analysis of possible origins of such ethnic differences because of different cultural socialization patterns see Okonji, 1980).

The Science Questionnaire differences (both sex and European/Maori) reveal the essence of this particular research problem - girls and Maori students (no statistically significant European/Pacific Island student differences were apparent) did not score as well as boys and European students (compare the means: Boys = 3.2; girls = -6.1; Europeans = 1.2; Maori students= -10.4; Pacific Island students = -4.2). Why is this?

These differences could suggest that the 'Children's Science' (see LISP working paper number 28) brought to the classroom by different groups of students differs. The reasons for these children's science differences could be due to experiential factors operating along linguistic, cultural, and societal stereotype patterns, eg, boys are more likely than girls to have had experience with manipulative toys which illustrate and allow for practice with fundamental scientific concepts such as cause-and-effect relationships; levers; momentum; electric current; sound; light; chemical change - girls may have had considerable experience with biological phenomena (animals, plants) but traditionally are more likely to have had toys requiring a more 'passive' response (eg such as dolls; playing house) (Kelly, 1981).

Ethnic differences, as well as being influenced by similar social factors as those which could result in the sex differences in children's science, could be compounded by language differences, eg, different ethnic groups may well develop different concepts to similar pivotal scientific words, such as 'force', 'work'. Within the culturally European-dominanted classroom, minority-held concepts could not be recognised and give rise to responses judged simply as 'incorrect'. The Cognitive Style and the Field Independence measures used in this investigation would support this possibility.

The distribution of responses on the attitudinal section of the science questionnaire revealed that significant sex differences occurred on all those items which related to an affective dimension (ie that of interest, enjoyment, and ease). Ethnic differences occurred on the items which tapped into perceived parental encouragement (European/Maori); desire to obtain a scientific job (European/Pacific Island); knowing a scientist (European/Maori). In each of these items the European students' responses were the more positive. Aspects of these findings reoccurred in the Final Survey also and are discussed more fully below.

(b) Pupil Interviews

When pupils talked about their school subjects and so on, they tended to comment primarily in terms of their attitude towards the subjects (like/dislike; enjoyable/unenjoyable) or their perceive value (important/unimportant; valuable/not valuable). Of secondary importance seemed to be whether they found the subject easy or hard, and how other people (usually parents) viewed the subject.

For example, one Maori fifth form girl's outlook clearly distinguished between the three school science subjects: -

Biology was seen as having some value although it was neither strongly supported by her parents; it was seen as a girl's subject; it was easily understood; and it was found to be fairly interesting. In terms of overall significance, the study of biology was not seen as being able to contribute to her goal of becoming an architect although it did contribute to an understanding of her environment and culture, and so, was allied with non-career type pursuits such as craft-work, Maori, and art.

Chemistry was a subject she had no strong feelings about, and, whilst it was not particularly easy nor particularly difficult, she could not see it as being personally relevant to her needs. She considered it to be neither 'feminine' nor 'masculine'.

Physics was seen as not having as great a personal value as Religion, Maori, English, and mathematics, yet it was more valuable than other school subjects. It was seen as being somewhat masculine, difficult, and was clearly seen as being necessary for her chosen career, although it was found to be somewhat boring.

Another girl, a European third former, had no strong views on her school science other than it was a little hard and was perhaps more of a boy's subject than a girl's.

> "... there's more men inventors and all that sort of stuff, and I like it, but I don't know if I'd like to go into it as a job."

She had firm ideas of becoming a translator and of travelling so the subjects of German, social studies, and of English tended to dominate her thinking of school subjects.

> "The one I like the best is German. That's quite important but the one I think is most important is English, and maths, and then science, maybe. Those are the ones you really need. (Why do you put those so high up?). Well, because to get School C and UE. For School C you need English and maths. I don't know about science ... everyone reckons that science is a good one to take."

To summarise the outlook on science of all the students interviewed is difficult. However, individual perspectives on the position of science within these students' minds were discernible and, whilst no consensus of opinion was obtained (nor was it anticipated), the following beliefs can be considered to be typical:

(i) Science was not seen as being particularly enjoyable nor important, unless the student saw it as either being of importance for a specific career or found it relatively easy.

"I can't see any way in which it (science) can be directly applied to us, or to our environment." (F4 girl)

(ii) Science (particularly the physical sciences) was perceived as being inherently difficult.

"Friends would think you were crazy (if you took science) because it's so hard." (F4 girl)

(iii) Some sex stereotyping was suggested (Physics was masculine; biology was feminine).

"Science is for boys and stuff like English is for girls ... you don't really see many female scientists." (F5 boy)

"Everyone says that girls can't do physics and so you think you can't do it." (F6 girl)

(iv) The perspectives of parents and peers were evident in many pupils thinking.

"Yeah, jokers like me say how hard it (science) is and young fellas get hold of this." (F6 Maori boy)

"Nana believes I could do without science as she thinks it's not important - I'd be better doing something like Home Economics, Clothing, etc." (F4 girl)

(v) English and maths were seen as being more important school subjects than science.

"You can see the reason for learning maths, and you can see the reason for learning English, but you can't apply much of, you know, molecules or an atom, or something, to your everyday life." (Samoan youth)

(vi) The function of the school was perceived primarily as being to prepare pupils vocationally, and science was not seen as being pertinent for most jobs or careers.

"(Schools are) to get you ready for jobs later on in your life."
(F5 boy)

"Oh it's good to do chemistry and biology because if you need it later on - if you wanted to change your job, you've got a background to it, and you can go and specialise in it."
(F5 boy)

(vii) The 'everyday' application and contribution of science was rarely recognised.

"I don't think I would ever use it. I don't really want to know how far a projectile will land."
(F4 girl)

(c) The Parent Interviews

As indicated in the preceeding section, the parent interviews were unstructured and, as such, identical questions were not asked of each parent, although the same general ones were covered. A few typical responses to these general areas are given here.

(i) The function of the school

The parents' perceptions of the role of the school in society was explored early in the interview as part of the getting-to-know-you phase, as it was felt an immediate focusing of attention on 'science' could deny the opportunity to elicit the parents' less tangible overall orientation to school in general.

Virtually every response reflected the belief that the school's prime function is to prepare children for the work force.

"To prepare the kids for when they are ready to go out and get a job." (Mother)

"To make them get their education - to get into a good job later on." (Father)

(ii) Important school subjects

In following this general area, parents were usually asked which particular school subjects did they consider to be the most important. Again, the responses were unanimous: English and maths.

"Well, I've always thought English and maths were the two most important (subjects)". (Father)

"If you don't understand English and all that, if you're out to get a job, you won't get anywhere ... (and maths is important because) I suppose you're going to come up against figures, and all that." (Mother)

(iii) What is science ?

Parents were asked to define or to explain what is involved in science. Very few parents had a clear understanding of what science is.

"I think science makes you think. I don't know a lot about science, but what I hear you know, and all these atoms and Christ knows!" (Mother)

"I don't know much about science, nothing at all as far as science is concerned. .. You see, at the time when I was going to school, there was no such thing as science in that time ... When I came to New Zealand, that's the first time I hear about science, you know."
(Cook Island father)

(iv) How necessary is a knowledge of science in the everyday world?

In following up the parents' explanations of science, the perceived relevancy of a personal knowledge of science was explored with them.
(Interviewer - "Why teach science?")

"Gosh! Well we're surrounded with - gosh, it's everywhere around us, isn't it? We have living things all around us - we need to be aware of what's going on around us. Surely we take an interest in why things happen, how do they happen, why is this different to something else? Why is this bigger, larger, thinner, heavier?" (Father)

However, this was an isolated response. More typical were: -

"I suppose I'm sort of fairly biased about it (science). I don't care about it, to be perfectly honest. I don't, cos I was hopeless at it and therefore I don't expect - you know - if my kids do well at it then I'm pleased because I'm pleased at anything they do well, but if they're hopeless at it I can understand because I was hopeless at it. (Mother)

"I just see it as an academic subject and if you've mastered your English and your maths ... it just makes you look into life maybe differently or something. That's how I feel about science." (Mother)

The next quotation illustrates the reliance parents have on their children's own attitudes and beliefs about science as a school subject; even though, as will be shown later, children are influenced by their parents' beliefs and wishes, the parents are, in turn, influenced by their children's outlooks on science.

"We really haven't got a terribly good idea on what - you know - what it (science) really covers."

(Interviewer: So when you're in a situation like this, where do you get your advice from? There is the possibility of your son taking science, are you influenced by his comments, and so on?")

"Oh yes. Yes, very much so."

(v) Who studies science?

Another aspect of the parents' beliefs was related to their perception of the kind of people who would want to study science beyond school and, by implication, whether their children would be seen as showing similar characteristics. The following excerpt from a transcription typifies the common parental response:-

Interviewer:	What sorts of people become scientists?
Father:	I think possibly, the brighter ones, you know ...
Mother:	You said 'scientists' - you know - I sort of think of professors or something like that ...
Interviewer:	... So you see science as being a fairly academic, or a fairly abstract, sort of subject?
Mother:	Yeah.
Father:	Hmmm (affirmative).
Mother:	Yes, somebody - the real, the bright - the brighter ones. I couldn't really see Leanne in that category, could you?
Father:	Not at this stage.
Mother:	No. To me, she's just an average student. I couldn't really see her going into depth into science, or anything like that.

As another parent, a father, so eloquently expressed it:

"I've always thought of brainy people, you know, done science!"

(vi) Sex differences and science?

Although sexual equality is an expressed desire in much of society, many mothers gave the impression that they would wish to retain their traditional sex-role stereotyping in which preparation for a long-term career was more appropriate for boys.

"You know, you can't lump the boys and girls together. It doesn't matter what you say, you just cannot lump them together! You know, they're meant to be different otherwise there wouldn't be boys and girls! I don't believe in this total equality, I'm afraid, perhaps I'm old fashion, but I believe we were meant to be different, and that's that!"
(Mother)

This sentiment was repeated in several guides, with many mothers claiming to be very contented with their domesticated (unliberated?) role:

"I'm liberated in my home and that's all that matters, and that's what I tell everybody!" (Mother)

The nett effect of such beliefs on the outlook of girls on science is probably indeterminable but it is suggested that it would not be insignificant. Particularly in Polynesian families where traditional sex-roles are often still strongly held, eg,

Father: As far as I can see, why the girls turn away from studying science, it's not very important for girls, particular, because sometimes they go by themselves and they can't leave them with science for a living - then they get married - then they finish with it - with the study. But the man - got the big family, or what-ever, has still studying and living in the - I think that's what it is ... the science is too far - study, study. Not like English and arithmetic - for the science you have to study for the facts too much. For what effect?

Interviewer: So you see that the males, perhaps, have got a longer term career?

Father: Yeah, yeah.

Interviewer: And that's where science fits in - whereas with girls, their future is what?

Father: Very short. When they marry, then they finish.
(Samoan father)

(vii) Ethnic differences and science?

When interviewing Polynesian parents attempts were made to elicit explanations as to why relatively fewer Polynesian than European students studied the sciences. Often the responses reflected a simple lack of knowledge as to what was involved in science:

"For myself, my parents never gave science a thought and probably, because their interests weren't there, that's probably why I never took an interest." (Maori mother)

"I know on science - I think, for the Pacific Islanders - maybe because there's no interest in the parents, perhaps this one has gone through the children as well, because there's no backing for them as far as science is concerned." (Samoan father)

One Samoan youth, in helping his parents respond to the interviewer's questions suggested that the influence of the home was considerable:

"In so much at home they're (the Polynesian children) brought up to use their hands and not their mind. And the science - it's very hard not to use your mind - if they can go into woodwork where they can enjoy it because it's easy and they can use their hands - all the kids are good with their hands - so if they're good with their hands why should they waste time in science? It's their point of view." (Samoan youth)

The Pacific Island parents placed considerable emphasis on the importance of education for their children. In many cases, the quest for education, better than they themselves experienced in the Islands, was an important factor in deciding to come to New Zealand. Considerable encouragement for their children to succeed educationally was evident in all the families interviewed, but it was often misguided and very little meaningful advice was able to be given to their children on how to study, or where, or from whom (other than the teacher) assistance could be sought.

"Even though we don't understand the way of the education system here - very much we don't understand much - but we have a fair idea what's the students' needs - so got that - their needs - we brought books and all those things - even we got the set of Encyclopaedia Brittanicas for them when they were in the third form - they use it but not to the extent we hoped for. We tried to encourage them to study because we know that the basic of a good education is study - we tried to encourage them but they still want their time - their free time." (Samoan father)

This parent offered the suggestion that the Maori way of thinking and feeling is inherently different to that of the European and that it was incumbent upon teachers to be aware of these differences and accommodate them:

> "I think it's more a relationship between the teacher and the child - if a teacher can relate and understand the Maori background, in the way they think and the way they feel, then they teach them through the medium of science, I think they'll be able to get through a lot more Maori students. In my experience, I think I feared European teachers ... (at) the college that I went to, they were all Pakeha teachers and I feared them quite a bit because of their difference - the differences of their knowledge of their subject, obviously, and what I knew myself, which was very, very little, and I was frightened to ask questions." (Maori father)

(d) Results of final survey

An open-response survey was first administered to 111 form 4 and 5 students in order to determine the nature and extent of the 'objective' and 'subjective' beliefs (refer to page 3 for a description of these terms) likely to be held by the majority of students at these form levels. The questions asked and the results of this survey are given in appendix D. From these data two closed response surveys to measure the various components of TRA model at the fourth and fifth form levels were constructed. These were administered to 152 fourth and fifth form students respectively.

Even when the liberty is taken of combining the Maori and Pacific Island data (to provide a 'Polynesian' sample), the analysis with two forms (Forms 4 and 5); both sexes; two ethnic groups; the three branches of science considered by the fifth form students (biology, chemistry,and physics); combined, as well as the separate student groups, gives five form 4 and 15 form 5 TRA models! Therefore, for convenience, only four representative models, the form 4 sex models and the form 5 ethnic chemistry models, are given. See figure three.

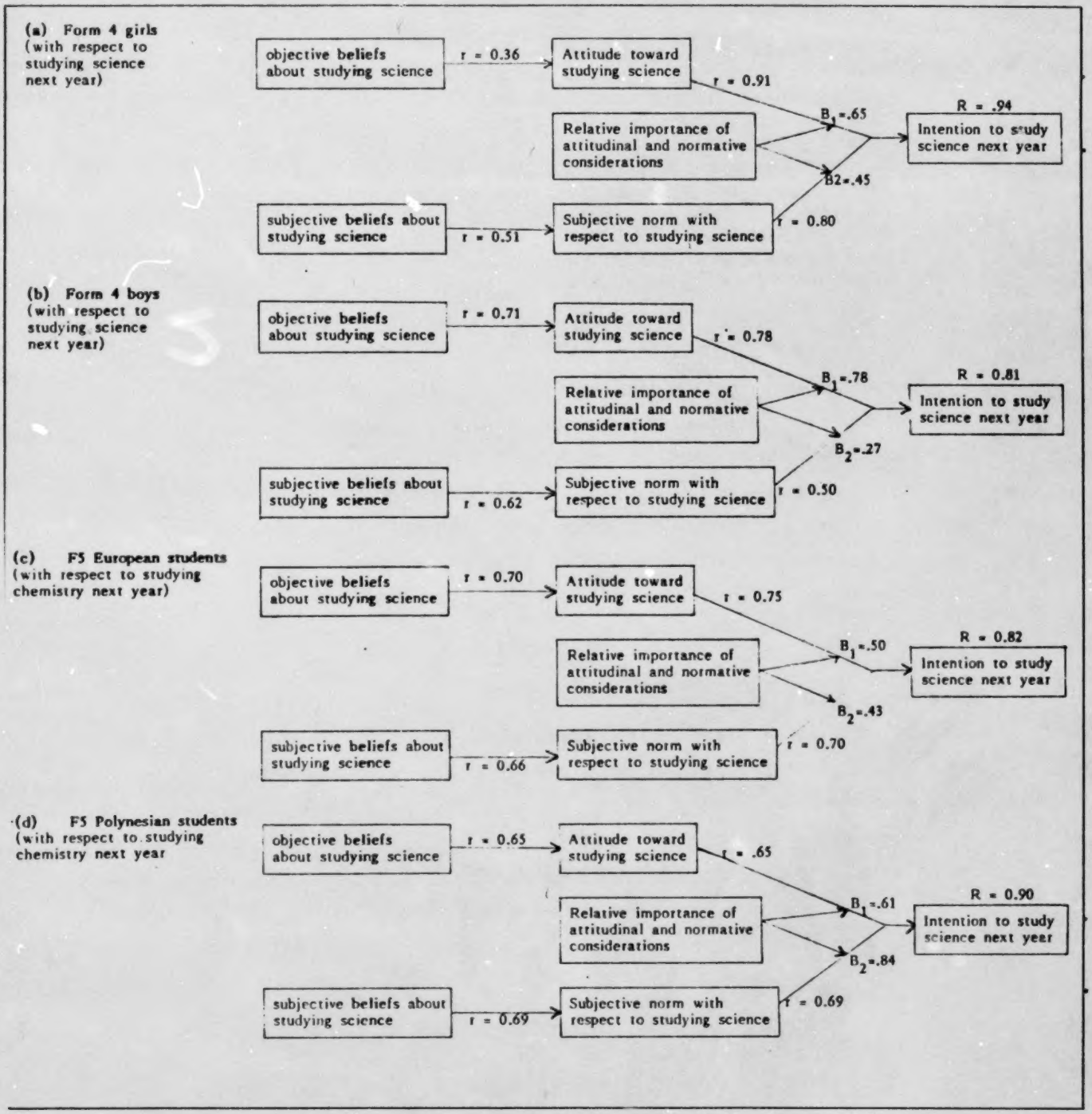

(a) Form 4 girls (with respect to studying science next year)
objective beliefs about studying science
r = 0.36
Attitude toward studying science
r = 0.91
Relative importance of attitudinal and normative considerations
B1 =.65
B2 =.45
R = .94
Intention to study science next year
subjective beliefs about studying science
r = 0.51
Subjective norm with respect to studying science
r = 0.80
(b) Form 4 boys (with respect to studying science next year)
objective beliefs about studying science
r = 0.71
Attitude toward studying science
r = 0.78
Relative importance of attitudinal and normative considerations
B1 =.78
B2 =.27
R = 0.81
Intention to study science next year
subjective beliefs about studying science
r = 0.62
Subjective norm with respect to studying science
r = 0.50
(c) F5 European students (with respect to studying chemistry next year)
objective beliefs about studying science
r = 0.70
Attitude toward studying science
r = 0.75
Relative importance of attitudinal and normative considerations
B1 =.50
B2 =.43
R = 0.82
Intention to study science next year
subjective beliefs about studying science
r = 0.66
Subjective norm with respect to studying science
r = 0.70
(d) F5 Polynesian students (with respect to studying chemistry next year
objective beliefs about studying science
r = 0.65
Attitude toward studying science
r = .65
Relative importance of attitudinal and normative considerations
B1 =.61
B2 =.84
R = 0.90
Intention to study science next year
subjective beliefs about studying science
r = 0.69
Subjective norm with respect to studying science
r = 0.69

Figure 3: TRA models illustrating the determinants of selected student groups' science choices.

The multiple correlation coefficients (R) in the examples are all high which indicates that student stated intention to study or not to study science can be predicted statistically by a simultaneous consideration of their attitudes to studying science and their subjective norms. The beta weights (B_1,B_2) can be taken as indicants of the relative importance of each independent variable in the prediction of intention.

For convenience, the male/female and the European/Polynesian differences are considered separately.

Male/female differences

In comparing figures 2(a) and 2(b) it can be seen that attitude is more predictive of intention than is the subjective norm, for both the girls and the boys. However, the relatively low correlation between the behavioural beliefs and attitudes for the girls' ($r = 0.36$) as opposed to that of the boys' ($r = 0.71$) would suggest that the determinants of attitude differ between the sexes, i.e., girls' attitudes are determined by factors other than just their beliefs about science, whereas boys' attitudes are considerably determined by their beliefs. One explanation for this is that boys generally have a wider range of out-of-school science experiences than do girls and so, have formulated a greater range of beliefs about science and, in evaluating them, are more likely to express positive attitudes. For example, contrast these beliefs from individual interviews:

> "Every job involves some sort of science whether it is carpentry or joinery." (Fourth form boy)

> "I can't see any way in which it (science) can be directly applied to us, or to our environment." (Fourth form girl)

Also, girls' intentions are approximately equally determined by attitude and by subjective norm, whereas boys' intentions are determined more considerably by attitude alone (see figures 2(a) and 2(b)). The repertory grid analyses and the individual interviews support this finding; girls were more likely than boys to mention the influence of others on their thinking.

> "Nana believes I could do without science as she thinks it's not important - I'd be better doing something like Home Economics, Clothing, etc." (Fourth form girl)

> "Friends would think you were crazy (if you took science) because it's so hard." (Fourth form girl)

European/Polynesian differences

In many respects, similar explanations to those above can be suggested to account for the differences between these student groups. However, whereas the fourth form boys, girls, and the fifth form European students' intentions were determined more by attitude than by subjective norm, the reverse is the case for the Polynesian students in this sample. This is, although both independent variables are important determinants of intention to study, or not to study, chemistry (in this example), the social influences appear greater (compare figure 2(d) with figures 2(a)-(c)).

The repertory grid technique and the interviews with parents again provided corroborative evidence. For example, Sandra, a Maori girl, although having been positively disposed toward her intermediate school level science, became ambivalent towards it during the first term at secondary school. She was an academically able student but she felt typing, cooking, and Maori were the most relevant, important, and the most interesting school subjects. These were the subjects most often discussed at home with her parents and were encouraged by her friends. She was unable to identify with most of her teachers on a personal level; the two exceptions being her Maori and 'tutor' teacher (a woodwork teacher). These latter teachers, she felt, were 'important', 'patient', 'interesting', 'helpful', and were people who do listen to me'. Sandra perceived that these teachers, her parents, and her friends, would not especially encourage her to concentrate on her science as it appeared to have little relevancy for her future needs - particularly those of a vocational and a socio-cultural kind.

Overview of Children's Outlook on Science and Implications for Teachers

The data collected in this investigation suggest that an individual student's outlook on science results from the interplay of many factors but thatgender and ethnicity do provide 'natural' lines of cleavage between individual students.

i.e. Boys did score higher on the Science Questionnaire; boys did express more positive attitudes to studying science than did girls; boys did have a wider set of beliefs about the likely consequences of their continuing to study science; boys' parents were more likely to encourage them, rather than their sisters, to prepare for a career (which might require a grounding in science); boys were not as influenced as girls by the perceived expectancies of other people.

Similarly, European students scored higher than Polynesian students on the Science Questionnaire; were more likely to express positive attitudes towards studying science (although Polynesian students were more likely than European students to take heed of the perceived thinking of these significant others).

Whilst statistically significant sex differences were evident in the field independent/ field dependent scores, and in the ethnic differences on this measure too; the positive IAR measure; and the descriptive and relational styles of thinking, the contribution these make to the differences in science outlook is not clear (a regression analysis on these data shows these variables do contribute to some of the Science Quesionnaire variance but, for practical teaching purposes, these contributions appear to be minimal).

Thus, although some researchers have consistently reported particular sex differences (eg Maccoby and Jacklin, 1974; Sutherland, 1981; with respect to such as those in spatial, verbal, and numerical ability, and field independence, field dependence) and particular ethnic differences (eg Reid, et al 1981; with respect to cognitive differences) which might appear to reflect a fundamental, perhaps innate, mechanism operating to differentiate between the student groups, it is suggested here that socio-cultural factors might be more profitably considered by the practitioner wishing to influence children's outlook on science.

i.e. Girls and Polynesian students develop outlooks on science which differ from those held by boys and Europeans because society does not encourage, nor expect, members of the former student groups to achieve as well as those of the latter groups.

e.g. "You mainly see on science fiction movies, or dealing with science, mainly see men and you hardly ever see any woman (scientist)."
(Form four student)

"I think that most Maoris think that the Maori's going to end up doing average jobs." (Form six Maori boy)

"Maori students feel they don't know anything - they feel as though they're the underdogs all the time so they feel as though school's not for them so they pull out."
(Form six Maori boy)

Thus, the lack of positive role models (eg female and/or Polynesian people engaged in scientific activity) is perceived by students and parents alike. Recently, the Research and Statistics Division of the New Zealand Department of Education (1980) carried out a survey on the incidence of sex-role stereotyping in school science text books used in New Zealand schools (6 primary, 4 secondary, and 5 teachers' books were examined) and found: -

> "Six times as many roles were assigned to males as to females overall. The ratio in reference books and primary text-books was 5:1, in secondary text-books the ratio was 6:1, and in teachers' books the ratio was 7:1.
>
> ... The ratio of the number of activities performed by males to those performed by females is 2:1 for primary text-books and teachers' books, 4:1 for reference books and 9:1 for secondary text-books.
>
> ... In all groups of text-books illustrations of males outnumbered illustrations of females. Primary and teacher text-books showed a ratio fo 3:1 and secondary text-books a ratio of 7:1.
>
> ... Reference to famous people in total ran heavily (about 19:1) in favour of males. Although people referred to by initial(s) were classified as neutral a more accurate count would probably have included these people as males, for when a female was mentioned her first name was usually used."
>
> (NZ Dept of Education, 1980)

Unfortunately, no such analysis was made for ethnic differences in role stereotyping but a similar (possibly greater) pattern of bias is expected.

Comment has already been passed (see page 5) on the possible effect on Children's Science of different early experiential and socialization patterns. It can also be suggested that the lack of positive role models, in the school, the work-place, and the media at a time when the students are becoming aware of their own identity and possible future plans, compound with these earlier experiences to result in an outlook on science which is rarely systematically examined or challenged.

Therefore, it may be strongly suggested that because these outlooks have such an important, and often a critical, influence of decision making and are too rarely consciously recognised by those involved in the decision making process (students, parents, and teachers) their development and monitoring should not be left to chance.

Consequently, several suggestions can be put forward to allow for a more ordered development, and a more rigorous examination, of children's outlook on science to occur.

(i) Students do not have a clear idea of what science is, how relevant it is (both in everyday sense and in a vocational sense) to them, how the disciplines within the general area of 'science' (biology, chemistry, physics) differ, or even why they are being taught science at all.

"You do it because it's on the timetable."
(Form three girl)

ie Student beliefs about science need to be explored, challenged, modified, and extended. We, as teachers, should regularly set aside time to ask our pupils such questions as, "Why do you think you do (or do not) need to study science?" "Is science necessary (worthwhile, valuable, important, etc)?" "What is science?" "How does science differ from your other school subjects?" "Why do you think that is so?" "Who uses science, in their jobs, in their everyday life?" "Where would science not be appropriate?" "Why not?" "To what extent has science changed our world for better and for worse?"

(ii) Students are influenced by their own perceptions of other people's views and even if these perceptions of other views are accurate, because these other views are likely to be limited (and often negative - particularly when they are those of peers) and of the traditional stereotype, the students are likely to be misled by these views. Particularly if their own independent set of behavioural beliefs about science is restricted.

Therefore, students' perceptions of other people's views (including the students' perceptions of their teachers' views too) would need to be identified explored, challenged, etc., e.g., we would need to ask them such questions as, "What do you believe your parents think about you studying science?" "What do most other people think about studying science?" "What do you believe I think about your studying science?"

(iii) In particular, because of the considerable influence the students' parents have in decision making (even though this influence is often tacit, it is very pervasive) parents' own outlooks on science need to be developed beyond those which they themselves had developed at school. The following are fairly typical comments which illustrate this point, and, although obviously are very general, do have some influence on the developing outlooks of the parents' children.

"I always thought as science is, you know, to do with plants, animals, anything - you know - that way. Laboratory doing - oh, science at school, sort of dissecting frogs ... I'm not fully aware of what science, you know, how big a field science covers now. I don't know about science."
(Father)

"My concept of science at school was where we had two periods a week and that was in the laboratory and that was it. You know - I sort of - I work in an office so, you know, I suppose I don't really know what field science covers really."
(Mother)

Several parents expressed concern about feeling very inadequate when attempting to give subject choice advice to their children, and others preferred to leave the decisions entirely to their offspring - this appeared to be particularly so of Pacific Island parents who professed ignorance of the New Zealand education system.

Some parents, in realising the limitations of their own knowledge, did make suggestions as to how the 'problem' might be tackled, e.g.,

"This is an area where parents are not aware of the subjects involved - although the school down here, they go to, is very good - when you go to parent interviews and that, there's usually that many people and you've got about five minutes with each teacher, and something like that. But when it comes to deciding what subjects children are going to take, I feel there could be more scope for parents to go along and learn more about the subjects.

... To have, say, a teacher give a discussion on each subject ... to give you a bit of depth in what the subjects involved so you are able to help the family make the right decision, or at least understand what they're doing more ... The whole education scene has changed that much since we were going to school and we really don't understand half of what they do."
(Father)

Consequently, it is suggested that we need to 'sell' our subjects more assertively and, in being aware of our students' social contacts' (particularly the students' parents) limited set of beliefs about the value, nature, and function of science in today's world, to provide for the development of positive outlooks in these contacts too.

Perhaps school guidance personnel could help us here, not merely to provide vocational advice but, to help broaden the students' sets of beliefs on the contribution science can make to everyday living. We need to extend the perceived role of schools held by many in society, that of vocational preparation. Particularly where, in today's world, the prospect of full-time employment for all school-leavers is open for conjecture.

The communication of positive outlooks to students within the classroom/laboratory is an accepted part of the role of the science teacher, but if the under-representation of particular student groups in science is considered to be in need of redressing, positive outlooks to science will have to be developed in those outside the school too. Perhaps we science teachers need to 'look-out' beyond our science classrooms?

REFERENCES

Ajzen I & Fishbein M (1980) Understanding Attitudes and Predicting Social Behaviour Prentice-Hall, Inc., Englewood Cliffs, NJ.

Archer E L (1970) The Interaction of Selected Instructional Procedures with some pupil variables. A pilot study. Unpublished MA thesis, Massey University.

Ausburn L J & Ausburn F B (1978) Educational Communication & Technology, 26 (4): 337-354. Cognitive styles: Some information and implications for instructional design.

Crandall V C, Katkovsky W & Crandall V J (1965) Child Development, Part 1, 36 91-109. Children's beliefs in their own control of reinforcements in intellectual-academic achievement situations.

Ekstrom R B, French J W & Harman H H (1976) Manual for Test Kit of Factor-Referenced Cogritive Tests. Educational testing service, Princeton, NJ.

Harker R K (1976) Achievement, Cognitive Style, and Ethnic Group Membership. Unpublished Ph.D thesis Massey University.

Kagan J, Moss H A & Siegel I E (1963) "Psychological significance of styles of conceptualization" in Wright J C, & Kagan J (eds) Monographs of the Society for Research in Child Development. 28 (Part 2, 86). "Basic Cognitive processes in Children".

Kelly A (Ed) (1981) The Missing Half: Girls and Science Education Manchester University Press.

Kelly G (1955) The Psychology of Personal Constructs, Volumes 1 and 2 Norton, NY.

Maccoby E E & Jacklin C N (1974) The Psychology of Sex Differences. Stanford University Press, Stanford.

Okonji M O (1980) "Cognitive Styles Across Cultures" In Warren N (ed) Studies in Cross-Cultural Psychology, Volume 2 Academic Press London.

Reid N, Jackson P, Gilmore A, & Croft A (1981) Test of Scholastic Abilities: Teacher's Manual. New Zealand Council for Educational Research. Wellington.

Stead K E (1981) "My Model or Yours?" Exploring an Individual's 'Outlook' on Science with the Repertory Grid. Paper presented to the New Zealand Psychological Society's Annual Conference, Victoria University, Wellington, August.

Sutherland M B (1981) Sex Bias in Education Blackwell, Oxford.

APPENDIX A: The final section of the Science Questionnaire. The responses made to these statements by those pupils chosen for the individual interviews were subsequently discussed with each pupil. The resultant data arising from the discussion provided the raw Repertory grids (Stead 1981)

SECTION THREE

How much do you agree or disagree with each of these statements?

Tick your choice

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. I find science interesting.					
2. I enjoy doing science experiments.					
3. My parents encourage me to take an interest in science.					
4. I would like to get a job which deals with science.					
5. I find science pretty easy.					
6. I read a lot about science.					
7. I like watching science programmes on TV.					
8. I know someone who is a scientist.					
9. I will never need to know much about science.					
10. I think girls find science harder than boys do.					

APPENDIX B: Summary of the characteristics of the students in the sample.

No.	Student	Sex	Age	Ethnic Group	Form[1]	School Type	TOSCA Raw Score	TOSCA Percentile	Hidden Figures[3]	Dominant Cognitive Style[4]	IAR[5] +I	IAR[5] -I	IAR[5] I tot.	Science Questionnaire[6]
1	Lei	M	15/8	PI	4	s/s city	49	87	11	C	13	11	24	+12
2	Louana	F	13/2	M	2	int. city	30	43	11	C	12	8	20	+8
3	Linda	F	14/6	E	4	s/s city	31	47	7	C	8	13	21	+2
4	Amanda	F	13/7	E	3	s/s city	37	72	12	D	8	7	15	-12
5	Robert	M	14/2	E	3	s/s city	37	66	6	C	15	9	24	+12
6	Peter	M	12/1	E	2	int. city	32	53	7	C/D	12	13	25	+2
7	Jackie	F	15/5	M	4	coed city	34	50	3	C	14	9	23	-4
8	Sean	M	11/11	E	1	int. city	37	78	10	D	12	13	25	+18
9	Wayne	M	12/2	M	1	int. city	33	58	6	D	10	12	22	-20
10	Murphy	M	13/10	PI	3	coed city	23	33	11	D	11	10	21	-6
11	Amanda	F	12/7	E	2	int. city	32	51	5	D	15	12	27	-6
12	Jackie	F	14/1	E	3	coed city	33	63	8	D	13	15	28	-2
13	Russell	M	13/9	PI	2	int. city	39	58	1	C	10	12	22	+14
14	Jocelyn	F	14/11	E	4	coed city	42	72	12	C	15	14	29	+40
15	Aroha	F	14/6	M	4	coed rural	35	54	13	C	11	11	22	+26
16	Susan	F	11/3	M	1	prim. rural	28	60	4	C	14	12	26	-26
17	Mini	F	12/9	M	2	prim. rural	32	50	7	C	9	11	20	-6
18	Andrew	M	14/6	E	4	coed rural	41	71	7	R	14	11	25	+10
19	Maurice	M	14/7	M	3	coed rural	44	85	9	C	16	14	30	+10
20	Sharon	F	12/6	E	2	int. rural	32	55	4	R	12	13	25	-16
21	Sandra	F	13/2	M	2	int. rural	30	43	-	D	14	16	30	-28
22	Angela	F	14/2	M	3	coed rual	22	22	9	D	13	13	26	-20
23	John	M	13/10	M	3	coed rural	29	45	5	C	14	11	25	-2
24	Leanne	F	12/5	E	1	int. rural	36	69	3	D	12	14	26	-12
25	Ruth	F	13/6	PI	3	coed rural	32	56	9	C	17	12	29	+6
26	Janis	F	14/6	PI	4	coed rural	41	71	9	R	15	16	31	+8

Notes:

1. As at the commencement of the study
2. Test of Scholastic Ability (NZCER, 1981).
3. Used here as a measure of 'Field Independence' See Ekstrom et al (1976)
4. R = relational style
   C = categorical style
   D = descriptive style
   See Kagan et al (1963)
5. These give the subscores and total score for the 'Intellectual Academic Responsibility' questionnaire See Crandall, Katkovsky, & Crandall (1965)
6. Possible range = $\pm$ 60; Mean = 1.63; s.d. = 15

APPENDIX C: Significant differences between the various student groups found by the instruments in the initial survey.

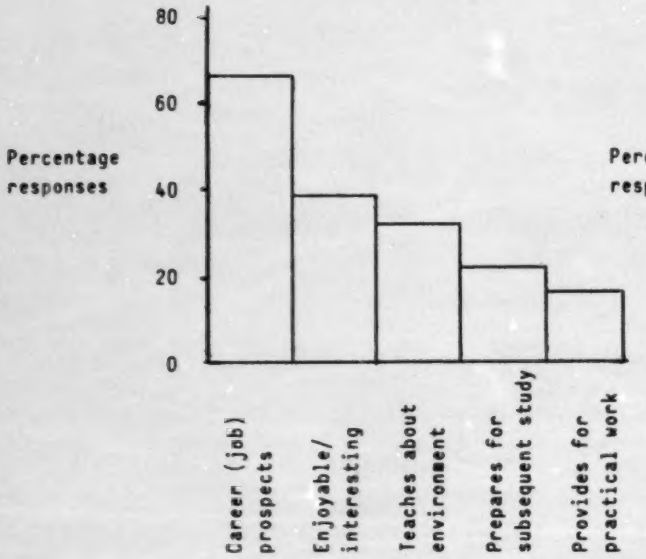
Instrument *N=	(i) Male/Female 260 - 280	(ii) E/M 340/133	(iii) E/P. I. 340/27
PAT:			
Reading	-	0.0001	0.0001
Listening	-	0.0001	0.0001
Vocabulary	-	0.0001	0.0001
Arithmetic	-	0.0001(N=106/47)	- (N=106/7)
TOSCA #	0.005	0.0001	0.0001
+IAR	-	0.001	-
-IAR	-	-	-
Categorical Style	-	-	-
Descriptive Style	-	0.02	-
Relational Style	-	0.001	-
FI/FD	0.001	0.001	-
Science Questionnaire	0.0001	0.0001	-
Attitude Section of Science Questionnaire:			
Q1 Interest	0.006	-	-
Q2 Experiments	0.0001	-	-
Q3 Parents	-	0.0001	-
Q4 Job	-	-	0.01
Q5 Science easy	0.008	-	-
Q6 Read science	0.0001	-	-
Q7 Science TV	0.0001	-	-
Q8 Know scientist	-	-	0.0001
Q9 Science knowledge	-	0.0001	-
Q10 Girls and science	0.0001	-	-

* Not all students were present for each measure

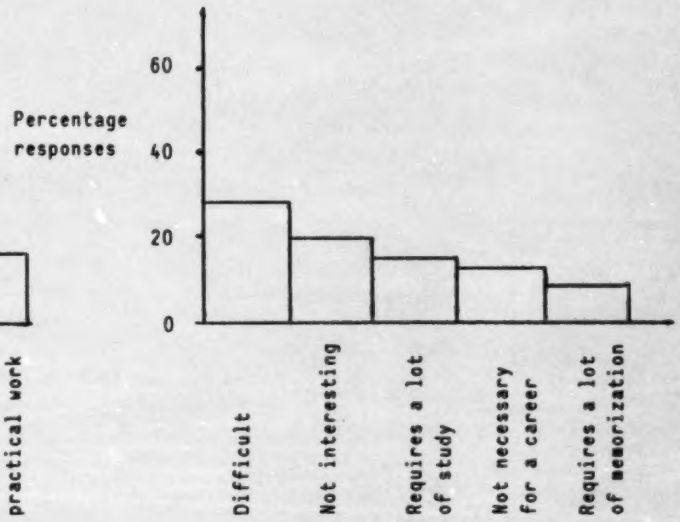
See notes to Appendix A for each variable

APPENDIX D: Questions and results of the Open Survey (N=111)

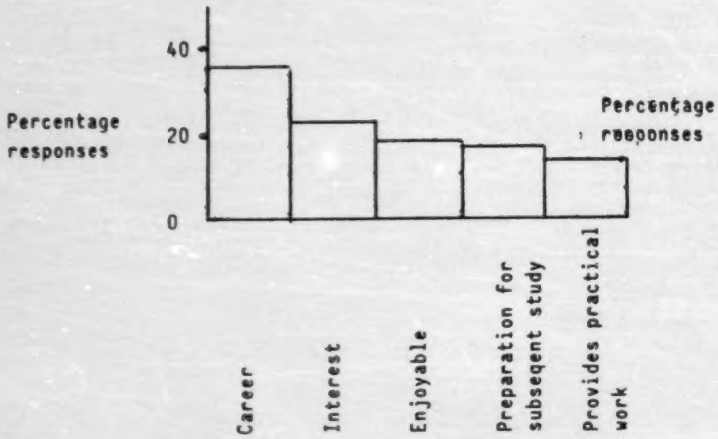
Question 1: What are tho advantages for you personally of studying science in Form five?



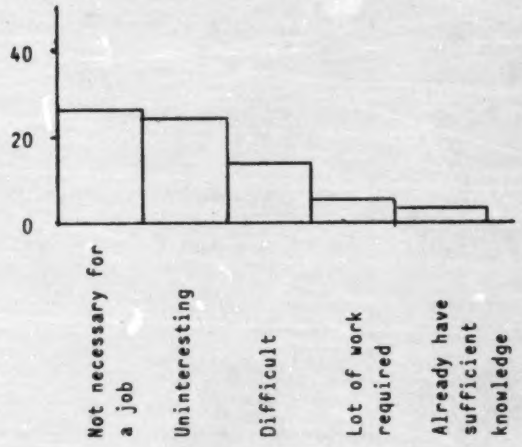
Question 2: What are the disadvantages for you in studying science in the fifth form?



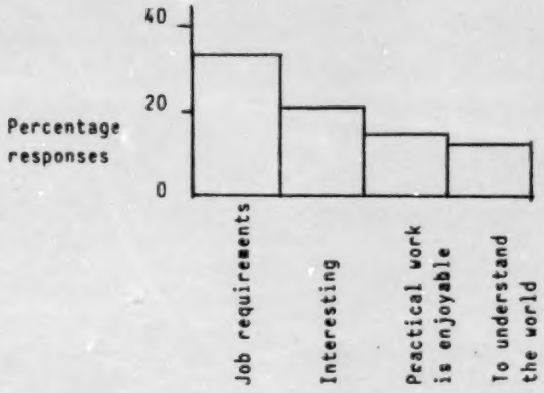
Question 3: What are the reasons why you might want to study Biology in the sixth form?



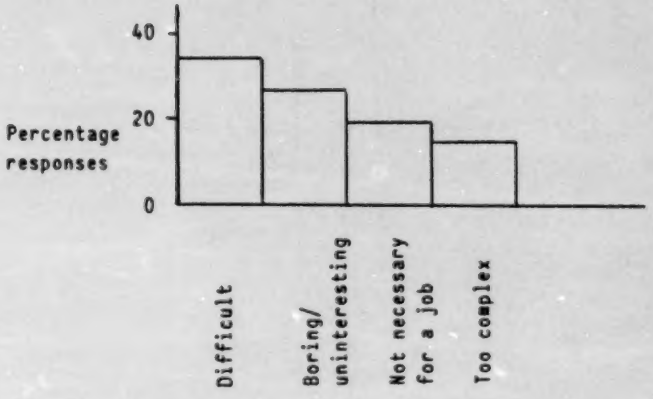
Question 4: What are the reasons why you might not want to study Biology in the sixth form?



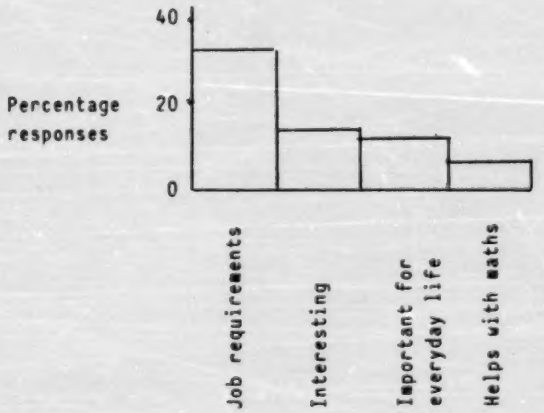
Question 5: What are the reasons why you might want to study chemistry in the sixth form?



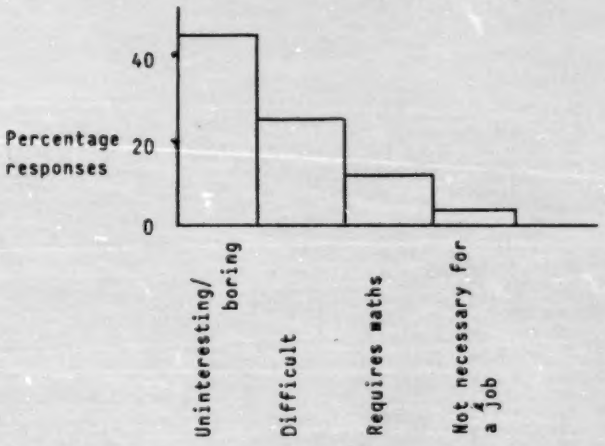
Question 6: What are the reasons why you might not want to study chemistry in the sixth form?



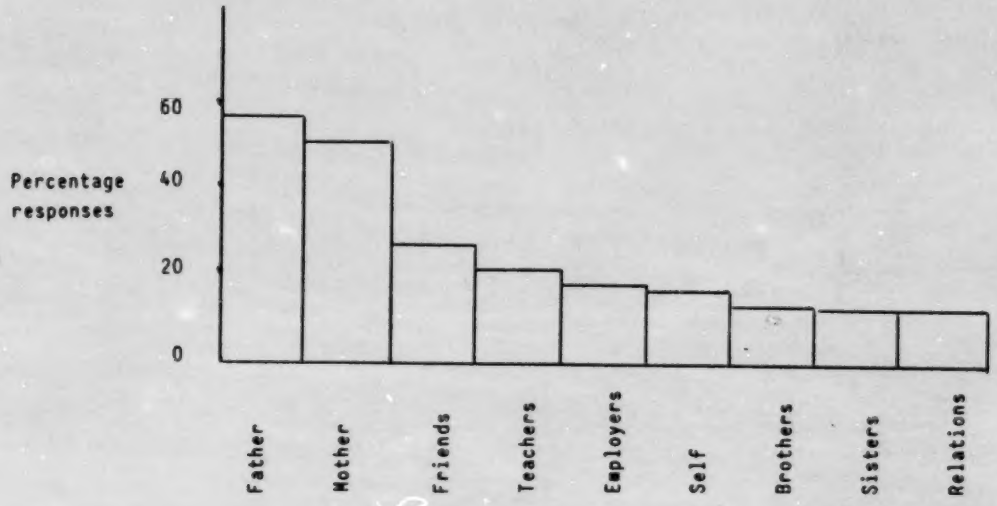
Question 7: What are the reasons why you might want to study physics in the sixth form?



Question 8: What are the reasons why you might not want to study physics in the sixth form?



Question 9: People considered to think science to be important for the students to study



Question 10: People considered not to think science to be important for the students to study